GPS failure, what then?

Impact on en route and terminal air traffic in an RNP environment

Session 3: Airspace Built-in Safety

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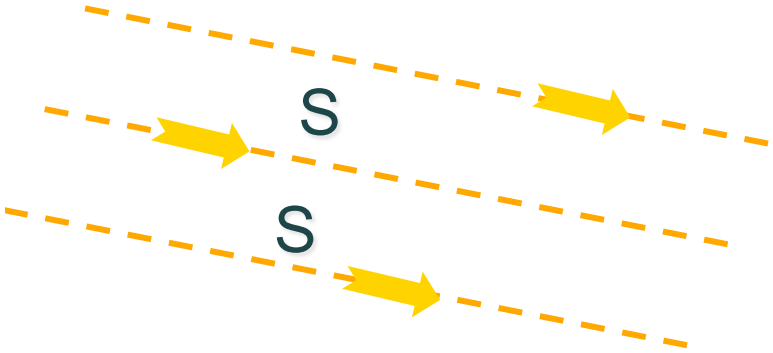
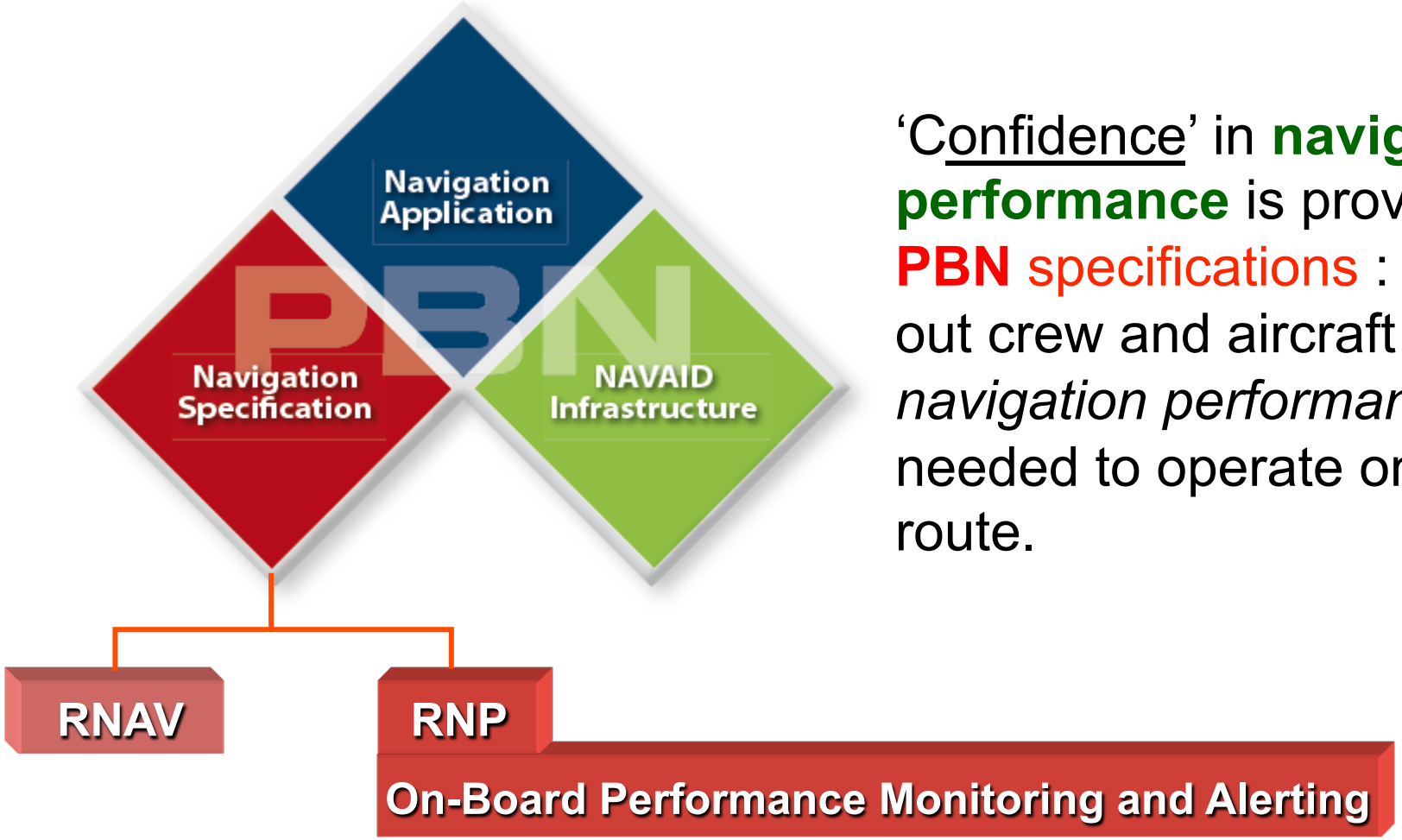
FSF 2014 Safety Forum
'AIRBORNE CONFLICT'

The airspace/navigation link



- ATS routes (incl. SIDs/STARs) are backbone of the ATM System
- For separation/spacing, ATC wants aircraft operating on the **route centreline**.
- To remain on route centreline, need good aircraft navigation performance.
- *P – B – N*

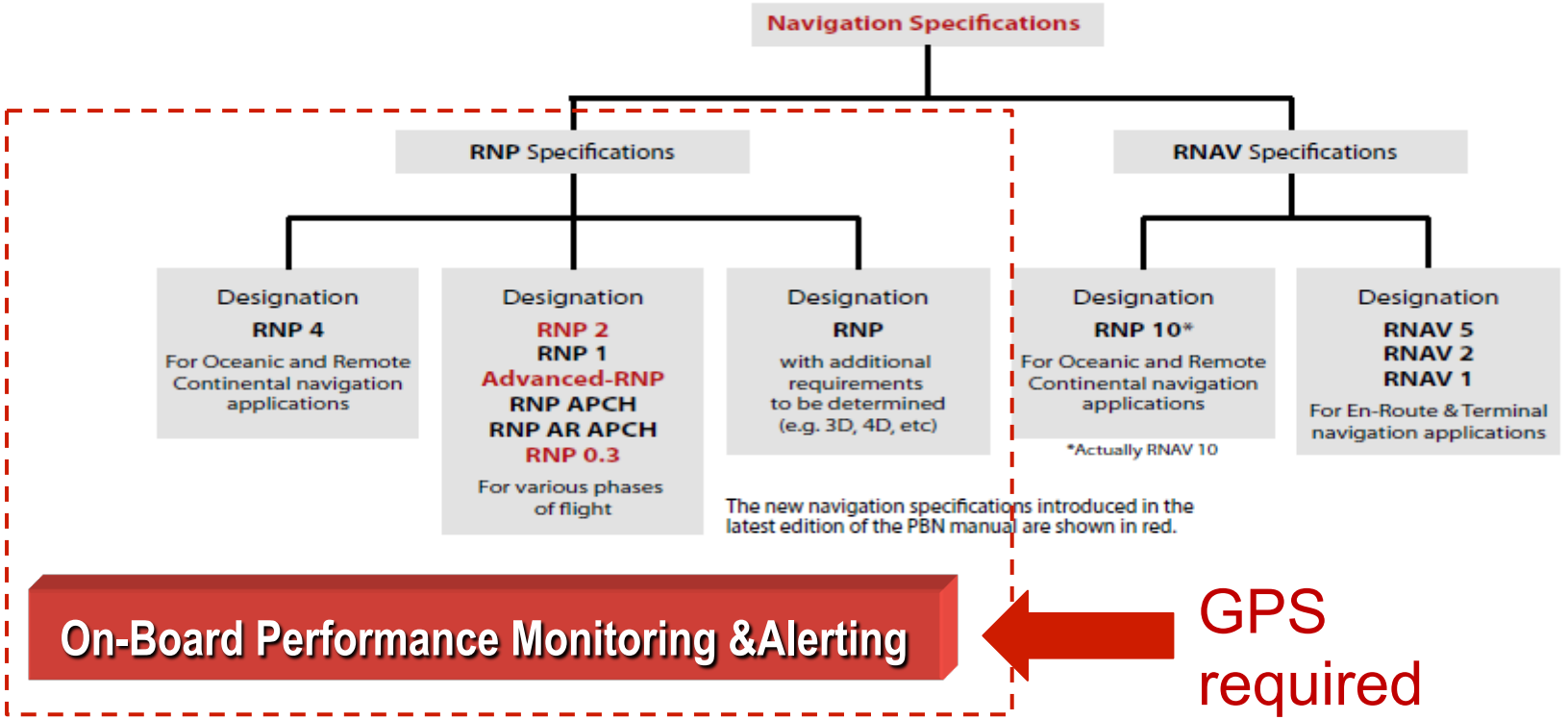
PBN & Airspace link



'Confidence' in **navigation performance** is provided by **PBN** specifications : spell out crew and aircraft *navigation performance* needed to operate on a route.

PBN Specifications

The name of RNAV or RNP specifications for en route and terminal mostly indicates the lateral accuracy requirements 95% of the flight time. E.g. RNAV 1 (1nm either side of track 95% flight time).

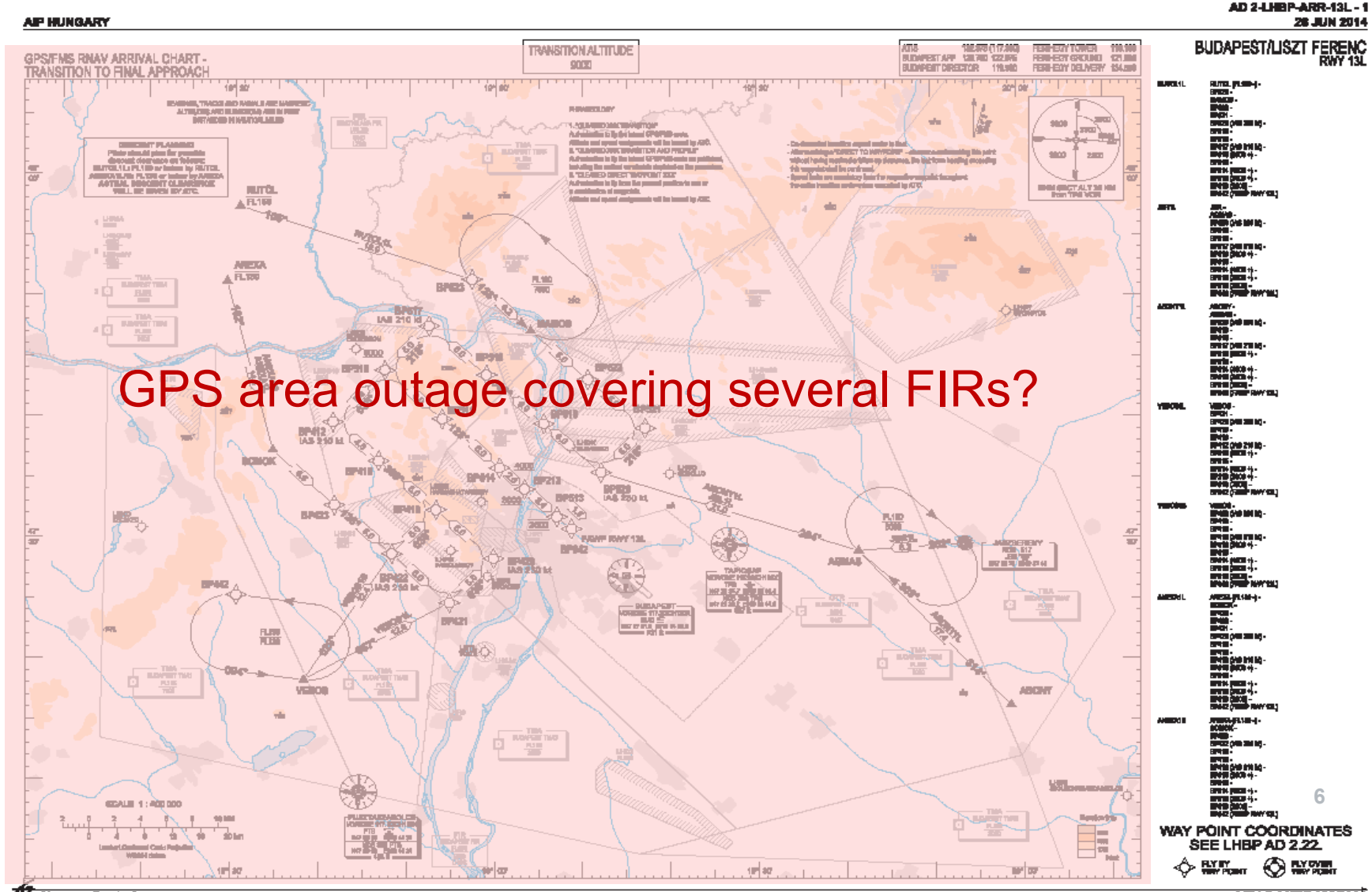


Airspace effects of PBN+

Parallel Routes / based on	Advanced RNP		P-RNAV		B-RNAV
	En-route	Terminal	En-route	Terminal	En-route
Same Direction	7 NM	7 NM	9 NM	8 NM	16.5 NM
Opposite Direction					18 NM
Other					10-15 NM with increased ATC intervention rates
Spacing on turning segments	As above using FRT en-route and RF for SIDs/STARs		Larger than above because no FRT		Much larger than above because no automatic leg change.

- How is the EN ROUTE and TERMINAL air traffic affected if there is an *area* outage of GPS? e.g. Unplanned outage due to jamming, space weather?

Effects of GPS ***area*** outage



Which viable alternative?

Before dual constellations available, need alternative positioning source to GPS with workable degradation to RNAV.

- ECAC has extensive DME coverage
- ECAC fleet well equipped with DME +/-IRU, but what of GPS only aircraft?

- ATC reversion plan needed
  - Dimension/duration of GPS outage area?
  - Which specific aircraft cannot navigate?
    - How many such aircraft can ATC accommodate?
    - Radar vectoring solution?
  - Impact on capacity?
  - Prohibit entry into affected airspace of GPS only aircraft?
  - DME/DME coverage on RNP ATS routes, SIDs and STARs.
  - DME/DME navigation accuracy good for RNP 1 routes +/- FRT/RF

Principles of Reversion* …

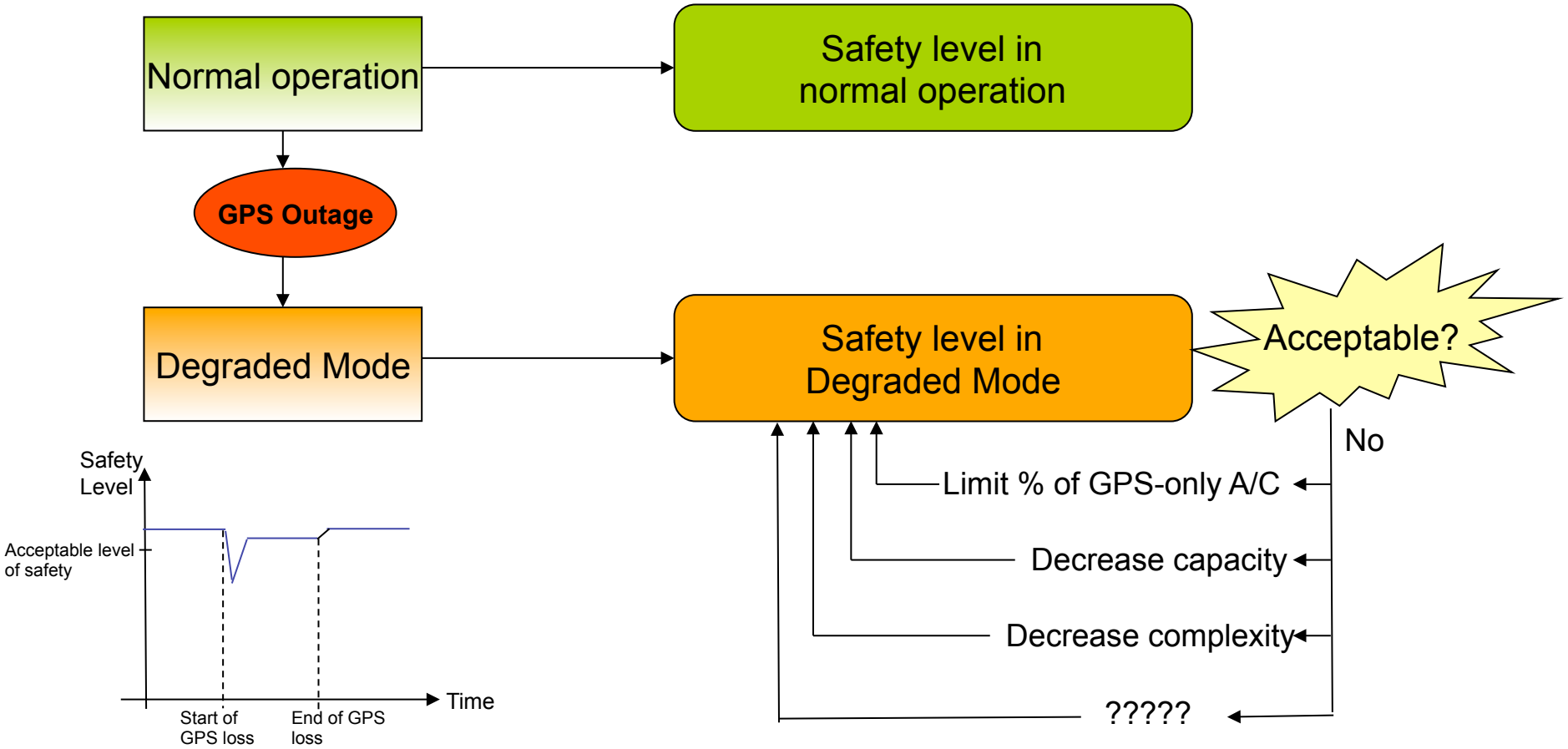
- Safe recovery of IFR/IMC aircraft
- Modify flight paths to avoid GPS outage area
- Continue dispatch of flights to deny economic target for intentional jammers
- Continue flight operations without significant workload for pilots/controllers

SESAR's 2014 simulations will examine whether graceful/safe degradation to DME/DME navigation is possible …. And how to handle those aircraft that only have GPS

* Principles comparable to those of FAA in A-PNT Conops

The Safety Claim to be considered

- Air operation in RNP environment remains acceptably safe following GPS outage (Robustness aspect)
- Must analyse the safety Impact in such degraded mode



Thank you

RNP Normal vs. RNP degraded mode

NORMAL MODE

- **FPL**
  - Indicate Sensors GPS/DME/IRU
- **Air crew HMI**
  - GPS status in PFD
- **Air crew procedures**
  - Notify ATC
  - Phraseology
- **ATM HMI (RDP)**
  - Sensors from ATC FPL Item 10 in extended Radar Label
- **ATC procedures**
  - Phraseology
  - Intervention

DEGRADED MODE

- **FPL**
  - Indicate Sensors GPS/DME/IRU
- **Air crew HMI**
  - GPS status in PFD
- **Air crew procedures**
  - Notify ATC
  - Phraseology
- **ATM HMI (RDP)**
  - Show GPS outage area
  - Show D/D coverage > FLX
  - In extended Label,
- **ATC procedures**
  - Phraseology
  - Control by exception
  - Remove non-DME aircraft
  - Capacity Regulation